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H2icpc pancreatic cancer
1992 deaths, Livingston
and Park County,
Montana

SUPERFUND

**Agency for Toxic
Substances and
Disease Registry**
Division of Health Studies

FINAL REPORT

**INVESTIGATION OF A CLUSTER OF
PANCREATIC CANCER DEATHS
LIVINGSTON AND PARK COUNTY, MONTANA**

**TECHNICAL ASSISTANCE TO THE
MONTANA DEPARTMENT OF
HEALTH AND ENVIRONMENTAL SCIENCES**

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**U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES
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**INVESTIGATION OF A CLUSTER OF PANCREATIC CANCER DEATHS
LIVINGSTON AND PARK COUNTY, MONTANA**

**TECHNICAL ASSISTANCE TO THE
MONTANA DEPARTMENT OF HEALTH AND ENVIRONMENTAL SCIENCES**

September 1992

This study and final report were partially supported by funds from the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) trust fund under Grant No. H75/ATH90029.

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ABSTRACT

A putative cluster of pancreatic cancer deaths in Park County, Montana, from 1980 through 1989 was investigated by the Montana Department of Health and Environmental Sciences and the Agency for Toxic Substances and Disease Registry (ATSDR) through review of death certificates and medical records. From 1980 through 1989, among white men residing in Livingston, the largest community in Park County, Montana, 11 pancreatic cancer deaths were observed compared with 4.7 deaths expected, based on U.S. rates (observed-to-expected ratio of 2.3). When rate for the state of Montana were used for comparison, there were 4.4 pancreatic cancer deaths expected and the observed-to-expected ratio was 2.5. (At the time of the analysis, U.S. and Montana rates were not available for 1989.) Smoking did not appear to be responsible for this increase. ATSDR recommends that a further investigation be conducted on this apparent cluster of pancreatic cancer deaths in Livingston, Montana.

INTRODUCTION

Residents of Livingston, in Park County, Montana, requested assistance from the Montana Department of Health and Environmental Sciences (MDHES) because they were concerned about potential exposure to groundwater and airborne toxicants. MDHES requested technical assistance from the Agency for Toxic Substances and Disease Registry (ATSDR) in identifying available options for health investigations or studies of residents of Livingston and the remainder of Park County.

In September 1989, MDHES requested ATSDR's assistance to determine health study options to address residents' concerns about an apparently high incidence of cancer in the area. Subsequently, MDHES provided cancer mortality statistics for Park County, Montana, to ATSDR from the Montana Cancer Registry covering the period 1986 through 1988 and asked ATSDR to determine whether there had been an increase in mortality from digestive tract cancers (which included pancreatic cancer) over background levels for those years. The Health Investigations Branch, Division of Health Studies, ATSDR responded to this request by conducting a preliminary investigation of cancer mortality in Park County.

OBJECTIVES

This study was conducted to achieve the following objectives:

- (1) Determine the numbers of deaths from pancreatic cancer from 1980 through 1989 in Livingston, in Park County exclusive of Livingston, and in all of Park County and to compare these numbers with the expected numbers of deaths from pancreatic cancer based on U.S. and Montana pancreatic cancer mortality rates for the same period.
- (2) Determine whether any association between pancreatic cancer mortality (by type of pancreatic cancer) and residential location, occupational history, or smoking was suggested by the information available.
- (3) Determine whether further evaluation of pancreatic cancer mortality was indicated in this community.

BACKGROUND

History

Environmental sampling conducted since 1985 in Livingston, Montana, has revealed widespread contamination of groundwater and soil by several toxicants, including diesel fuel and chlorinated volatile organic solvents (primarily degreasers) (Figures 1 and 2). Analyses of samples from monitored Livingston city wells revealed trace levels of these toxicants. For many decades, Livingston had been the site of a railroad repair and fueling station. In addition, two

sawdust burners in the southwestern and northeastern areas of the city and coal-burning locomotives generated smoke and emissions during operations prior to the mid-1950s.

The Northern Pacific Railroad's main line, which subsequently became the southern line of the Burlington Northern Railroad, runs through the town of Livingston along Park Street (Route 10) (Figure 3). MDHES officials reported that former railroad activities included routine idling of trains on the tracks in the center of Livingston to fire up (that is, bring to an operating condition from a cold or idle start) their engines. Under these circumstances, trains expelled large quantities of smoke and fumes on a daily basis for decades, suggesting a high magnitude of airborne exposure to toxicants during that period. However, the information was insufficient to quantify exposure.

Site Characterization

Environmental data collected since 1985 have demonstrated soil contamination with volatile organic hydrocarbons in the area of the railroad yard and groundwater plumes of diesel fuel, dichloroethylene, trichloroethylene, and perchloroethylene extending into the area between Park Street and the Yellowstone River and northeast of Main Street (Figures 1 and 2). At the time of the study, environmental data for air, surface water, and food chains were limited or unavailable; however, a planned ATSDR public health assessment and ongoing site investigations are expected to better define contamination of these media.

Sources of airborne toxicants may have included combustion products of coal, wood, and diesel fuel. MDHES indicated that two sawmills operated in Livingston for many years under varying kinds of environmental controls. In earlier years, sawdust burners were operated that tended to have inherently poor combustion characteristics. In addition, Livingston residents may also have used wood or coal in fireplaces or stoves to a greater extent than residents of other parts of the U.S. because of a colder climate. Availability of coal along the Northern Pacific line prior to the early 1950s might have encouraged residents to heat with coal. The smoke from locomotives probably also contributed airborne toxicants.

Initial Review of Health Statistics

MDHES provided ATSDR with the number of cancer deaths and mortality rates for Montana, Park County, and Montana exclusive of Park County for the period 1986 through 1988. MDHES classified these data into six major cancer site groupings (Table 1), and presented ATSDR with a copy of the results of a statistical analysis that suggested an increased rate of deaths from cancer of the digestive system and the peritoneum in Park County from 1986 through 1988 (written communication, March 14, 1990, memorandum concerning cancer in Park County, Montana, from Mr. Samuel Sperry, Chief, MDHES Vital Records and Statistics Bureau, to Mr. Donald Espelin, Chief, MDHES Preventive Health Sciences Bureau).

Based on this information and using codes listed in *The International Classification of Diseases, 9th Revision, Clinical Modification (ICD-9-CM) (1)*, ATSDR listed cancer mortality

statistics for five digestive system cancer sites in a contingency table. Expected numbers of deaths in Park County and observed-to-expected (O:E) ratios were calculated (Table 2). The O:E ratio exceeded 2:1 for two of the five sites: gallbladder cancer (ICD 156) and pancreatic cancer (ICD 157). Only two gallbladder cancer deaths were identified and could have occurred by chance even if statistical methods indicated significance. The total number of pancreatic cancer deaths was seven; thus, further investigation was warranted for the pancreatic cancer cases. Inclusion of other cancers previously associated with exposures likely for Livingston residents (on the basis of available environmental data) or of ICD-9-CM Code 156 cases was deemed unlikely to improve the chances of finding an association and, depending upon the approach, might have diluted any true association between residence or occupation and pancreatic cancer.

Pancreatic Cancer

Pancreatic cancer is the fourth most common cause of cancer-related mortality in men and the fifth most common in women (2). It is an insidiously developing, relentlessly progressive, and nearly universally fatal malignancy (3). Crude incidence has increased significantly in the United States with the increase in the median life expectancy of the U.S. population (4). Moreover, death occurs in over 95 percent of the cases (4). The male-to-female ratio for pancreatic cancer incidence is 2:1 in most patient series, and the mean age at which pancreatic cancer occurs is in the seventh and eighth decades of life (3). Pancreatic cancer rarely occurs before age 25 (3). It appears to be more common in blacks than in whites (4).

Occasionally, patients with pancreatic cancer manifest the signs and symptoms of chronic pancreatic diseases, such as chronic pancreatitis (3). However, no etiologic relationship has been established between acute or chronic pancreatitis and subsequent development of cancer of the pancreas (4).

Cigarette smoking is the most consistently observed risk factor for pancreatic cancer. Men who smoke more than 1.5 packs of cigarettes per day have a threefold increase in risk and women who smoke more than 1 pack per day have a twofold increase in risk compared with nonsmokers (5). It is not clear whether the apparent association between cigarette smoking and pancreatic cancer represents direct carcinogenesis by cigarette smoke metabolites or an undefined exposure that occurs more frequently in smokers (4).

One study reported a strong positive association between residence in higher latitudes and pancreatic cancer incidence and a strong negative association with average ambient temperature (2). However, these trends have not been confirmed when evaluated by other investigators (6).

In a Louisiana cluster of 876 pancreatic cancer deaths, approximate twofold increases in odds ratios were reported for oil refining and paper manufacturing workers, and slight increases were reported for residents living close to refineries and food processing plants (6). Currently available data do not link pancreatic cancer with risk factors such as alcohol abuse, diabetes mellitus, gallstones, or coffee drinking (4).

METHODS

Rationale for Study Design

ATSDR's preliminary analysis of cancer mortality information suggested an increased rate of pancreatic cancer in Park County during the period 1986 through 1988. As a result, investigators decided to review the available medical records of all persons who died of pancreatic cancer in Park County from 1980 through 1989 to confirm the accuracy of the diagnoses and to obtain available information on additional factors such as smoking, occupation, age at death, and residential history. They examined the population distribution by age and sex during this time period (from U.S. census data) in Livingston and Park County (7), and calculated the observed and expected numbers of pancreatic cancer deaths (from U.S. pancreatic cancer mortality data) in Park County, in Livingston, and in Park County exclusive of Livingston. Age-adjusted pancreatic cancer death rates were calculated for Park County, Livingston, and Park County exclusive of Livingston, and the associations between mortality and potentially confounding factors such as age at death, residence, smoking, and occupation were evaluated. Mortality was accepted as a substitute for incidence because the case-fatality rate is approximately 95 percent (4).

Case Definition

A case was defined as a death of any resident of Park County, Montana, during the period January 1, 1980, through December 31, 1989, whose death certificate was coded by nosologists in the "immediate cause of death" section as ICD 157. This code corresponds to pancreatic cancer in both editions of the ICD used during the period of study (ICD-8 and ICD-9-CM).

Study Area

The study area was defined by mailing address. Persons whose death certificates listed a Livingston address (ZIP Code 59047) were counted as residents of Livingston, and persons whose death certificates showed a Park County mailing address outside of ZIP Code 59047 were counted as having been residents of Park County exclusive of Livingston.

Medical Records Review

The address information shown on the death certificates was used to identify decedents who had resided in the study area. All were Park County residents who had died of pancreatic cancer during the study period, 1980 through 1989, and who were listed by the Montana Cancer Registry. Medical records librarians at the Livingston Memorial Hospital identified additional Park County residents who died of pancreatic cancer during the study period. Hospitals listed on the death certificates were contacted and the medical records of the decedents were reviewed.

Each medical record was read in its entirety, and a medical records abstraction form was completed (Appendix) using the following variables when available:

1. Local file and hospital record number
2. Age, date of birth, gender, and race
3. Procedures used to diagnose pancreatic cancer
4. Residential address
5. Length of residence at each indicated address (when available)
6. History of diabetes mellitus
7. History of smoking
8. History of alcohol use
9. Medications used (at the time of death and, as much as possible, historically)
10. Pertinent dietary history
11. History of other diseases
12. Occupational history
13. Spousal occupational history

Data Analysis

Deaths were tabulated for residents of the study area (male, female, and total) according to mailing address: Livingston (ZIP Code 59047) and Park County exclusive of Livingston. Expected numbers of pancreatic cancer deaths among white male and female residents were calculated using the U.S. and Montana death rates from pancreatic cancer (ICD-9-CM Code 157) for the period 1980 through 1988 (U.S. rates were obtained from unpublished final data, National Center for Health Statistics, 1988) (8). Neither U.S. nor Montana death rates were available for 1989 at the time of the analysis. Rates were calculated using the resident population 1980 Census breakdown by gender and age groups for the populations in the two areas (7,9). (Population data for the U.S., Park County, and Livingston were available by 5-year age groups, but data for Montana were available in 5-year age groups only through age 24, and then in 10-year age groups. Data for the U.S. and Park County were grouped in a single category for all people 85 years of age or older, but data for Livingston and Montana were grouped in a single category for all people 75 years of age or older. To avoid confusion, the term "age group" is used throughout.)

The Poisson distribution was used to calculate the probabilities (p values) of the observed number of cases occurring by chance in the two study areas and in Park County as a whole. The Bonferroni method was used to correct for the fact that the study hypothesis was tested with the same data that were used to generate the hypothesis. The Bonferroni method divides the chosen p value (conventionally 0.05) by the number of comparisons made (10). Since the data used to generate the hypothesis in this study listed five digestive-system cancer sites, the investigation used a p value of 0.01. Sex-specific, age-adjusted pancreatic cancer death rates were also calculated for the study areas and compared with the 1980 through 1988 age- and sex-specific rates.

Smoking history, occupational history, and residential location were classified according to information in the medical records of the decedents from both study areas. Decedents were classified as smokers if they had: (1) a history of smoking noted in their medical records, or (2) a history of having quit smoking within 25 years prior to hospital admission. Decedents were classified as nonsmokers if they: (1) were identified as nonsmokers in their medical records, or (2) had a history of having quit smoking more than 25 years prior to hospital admission. Decedents with no smoking history given were counted as unknown.

The crude and age-adjusted U.S. population prevalence rate of smokers in 1965, 1974, 1979, 1983, 1985, and 1987 ranged from 31.0 to 51.6 percent for males and from 26.5 to 34.0 percent for females (Table 3) (11). Because of typical latency periods between environmental exposures to carcinogens and development of clinically overt cancers, the critical time period for development of the observed pancreatic cancers probably was best represented by the 1965 prevalence rates. Therefore, a prevalence rate of 52 percent was used to calculate the maximum increase in the pancreatic cancer death rates of the study areas over U.S. rates that should have occurred in a worst possible case in which the percentage (60 percent) of smokers among the Livingston male decedents was applied to the entire Livingston population (Figure 4). Furthermore, in the absence of quantitative information concerning the smoking habits of all of the decedents, a threefold increase in risk (6) was assumed to apply to all smokers. This risk has been demonstrated among men smoking 1 to 1.5 packs of cigarettes per day (5).

Available residential locations of decedents were plotted on a street map of Livingston (Figure 3). This plot was used to look for any suggestion of a spatial relationship to possible environmental exposure sources.

RESULTS

Medical Records Review

Death certificates or medical records were used to identify a total of 23 residents of Park County who died of pancreatic cancer during the period of study. Of the 23 residents, 20 were identified using the Montana Cancer Registry and 3 were reported from Livingston Memorial Hospital medical records.

Of the 23 persons identified by death certificates or medical records as having pancreatic cancer, 20 met the case definition (Figure 5). Of these 20, 14 had Livingston addresses and 6 had Park County addresses outside of Livingston. To the extent ascertainable from the medical records, none of the 20 cases occurred in the same family.

Medical records were located for 18 of the 20 cases. Overall, 35 percent of the cases were histologically confirmed. The medical records did not provide adequate information to consider length of residence or spousal occupation in the analysis. In addition, four variables—diabetes mellitus, alcohol use, medication use, and dietary habits—were deleted from

consideration because review of the literature on pancreatic cancer indicated no valid associations with these factors.

Review of death certificates and medical records yielded information on age, occupation, and residence history for 100 percent and on smoking history for 80 percent of the decedents meeting the case definition. However, occupational and residential histories were limited, and much information of potential interest (such as length of residence at each address) was often not available. Medical records reviewed did not provide adequate information to consider spousal occupation in the analysis.

Characteristics of Cases

Livingston

Of the 14 decedents with Livingston addresses, 11 were men and 3 were women. Four of the men and one of the women also had a diagnosis or "probable" diagnosis of another type of cancer (Table 4). Categories of diagnostic criteria included clinical presentation in eight cases, including exploratory laparotomy in seven cases and abdominal ultrasound or computerized axial tomographic (CT) scan in seven cases. (In some cases, more than one of these diagnostic criteria were cited.) Of these eight clinically diagnosed cases, six lacked biopsy evidence of a malignancy either because no biopsy was taken or because the biopsy tissue did not reveal malignant cells. However, in all six cases, the medical records indicated a strong diagnostic impression of pancreatic cancer because of the location and pattern of extension of the pancreatic mass and other clinical features. In the seventh case, an abdominal CT scan revealed a pancreatic tail mass and metastases in the liver. The patient was cachectic and died before further diagnostic evaluation could be made. In the eighth case, the diagnosis of pancreatic cancer was questioned by the physician writing the final discharge summary.

Of the remaining six cases in Livingston, five were histologically confirmed (four adenocarcinomas and one islet cell carcinoma). The sixth died at home; no medical record or further information was available.

Park County Exclusive of Livingston

Of the six decedents with residences in Park County exclusive of Livingston, four were men and two were women. Two of the six cases were histologically confirmed as adenocarcinoma. Of the four remaining cases, two were clinically diagnosed, including one in which multiple biopsies did not reveal malignant cells and one in which the biopsy was interpreted as "probable" adenocarcinoma. Diagnostic details were not available for the other two cases. However, in one of these two cases, the listed causes of death included unrelated conditions that might mimic or confuse the diagnosis of pancreatic cancer.

Possible Risk Factors

Livingston

Of the 14 cases in Livingston, 6 were in persons who had a documented history of smoking during the previous 25 years (Table 5). All of the six were men. For a worst possible case estimate, investigators applied the observed percentage of smokers among the men with known smoking status (60 percent) to the entire Livingston male population. This calculation attributed only 7 percent of the increase in the pancreatic cancer mortality rate to smoking (Figure 4). In fact, smoking probably accounted for an even smaller increase in the rate because the percentage of Livingston males who were smokers was probably smaller than 60 percent.

A street address was listed for 11 of the 14 cases in Livingston; post office boxes were listed for the other 3. The location of the known addresses suggested a wedge-shaped clustering of nine cases around the railroad yard, with a tail of three cases east of Highway 89 (Figure 3). Of the three decedents who lived east of Highway 89, all three probably had regular occupational contact with the railroad yard. The arithmetic mean age in years was 73 for men and women in Livingston, and for women in Park County exclusive of Livingston; it was 67 for men in Park County exclusive of Livingston (Table 6).

The 11 Livingston men who died included 4 with occupational histories of railroad work (Table 7). The three Livingston women who died all had occupational histories as housewives.

Park County Exclusive of Livingston

Of the four male decedents in Park County exclusive of Livingston, two were counted as nonsmokers (Table 5); one of these two reported use of chewing tobacco only. Both of the female decedents were counted as nonsmokers.

The four men had listed as their occupations a mechanic; a retired accountant and rural letter carrier; and two ranchers, one of whom also had worked as a salesman. The two women were a schoolteacher and a school cook (Table 7).

Observed and Expected Death Rates

The O:E ratio for men in Livingston based on the Poisson distribution was 2.3 when age-adjusted for the U.S. population and 2.5 when age-adjusted for the Montana population. It was statistically significant for both comparisons ($p < 0.01$) (Table 8). No significant increase was found for women in Livingston or for either gender in Park County exclusive of Livingston. The age-adjusted rate among men in Livingston was 2.3 times the U.S. rate and 2.5 times the Montana rate (Table 9).

DISCUSSION

At the time of the study, no association had been reported between the occurrence of pancreatic cancer and the types of exposures (for example, volatile organic compounds, diesel fuel, and asbestos) that might be plausible (on the basis of environmental data and historic information about the railroad yard) for Livingston residents. This investigation included preliminary, case, and occurrence evaluations of a cluster of pancreatic cancer deaths (12). Heretofore unobserved associations between such an observation of a cluster of disease and an environmental risk factor might be evidenced strongly enough to warrant further investigation by meeting certain criteria (for example, Hill's modified postulates) and help to establish a casual relationship between the disease and risk factor (13).

The geographic plot of residences in Figure 3 suggested a clustering of cases around the railroad yard. However, a conclusion could not be made without also plotting the residences of similar people "at risk" who did not have pancreatic cancer (as might be done in a case-control study). This investigation did not obtain that additional information.

The worst case calculation of the effect of smoking attributed only 7 percent of the pancreatic cancer mortality rate to smoking (Figure 4). Thus, in this preliminary investigation, smoking did not appear to explain the observed elevation in pancreatic cancer deaths among men. While more detailed information on smoking history obtained in a follow-up investigation could better address this question, this study showed little if any effect.

The proportion of decedents (36 percent) with occupational histories of railroad work could have represented a cluster related to occupational exposure, but also might have simply reflected the fact that railroad work was common in Livingston. A comparison with the occupational histories of people who died of other causes would test the association of occupational factors. The proportion of decedents who had outdoor occupations might seem to suggest an environmental etiology, but also might have simply reflected occupational patterns in the area.

Limitations of Study Design

Cluster investigations depend heavily on the degree of case ascertainment, and the accuracy of diagnosis. Comparisons between populations are more valid when identical methods are used to identify and confirm cases, and a consistent case definition is applied. Therefore, although one of the Livingston decedents had a medical history that questionably supported a diagnosis of pancreatic cancer, the case was included in this study because the death certificate was coded as ICD 157, thus meeting the case definition. Furthermore, since the national reference set was based on death certificate codes and contained similar diagnostic problems, it would have been inappropriate to construct the case definition to exclude clinically doubtful cases from the statistical comparisons presented in this report. If a more extensive investigation is conducted, a more restrictive case definition may be used, and the accuracy of the diagnosis will be important.

This investigation was based on information taken from death certificates and medical records. These sources lacked important case information, such as the number of years of employment in each occupation, the different street addresses of residences, and the length of residence at each address. Given the incomplete environmental data and information on other possible risk factors, even rudimentary speculations about possible causes of the observed increase in age-adjusted pancreatic cancer death rate for men in Livingston were not possible in this descriptive epidemiologic investigation.

The percentage of cases with histological confirmation (45 percent among Livingston men) was similar to the percentages (30.5 to 50.8 percent) of histologically confirmed cases included in previously published studies of the accuracy of pancreatic cancer diagnoses (14-16).

The presence of other cancers was considered by the investigators as a potential basis for misdiagnosis. In this study, of those decedents with pancreatic cancer, five also had diagnoses of other types of cancers. One of the male Livingston residents had diagnoses of lung cancer and laryngeal cancer 10 and 15 years, respectively, prior to the pancreatic cancer diagnosis. Both cancers were considered cured because they did not recur or spread within 5 years of their original diagnoses. Thus, these earlier diagnoses did not explain the clinical presentation diagnosed as pancreatic cancer. Two other male Livingston residents had diagnoses of prostatic cancer—one 3 years prior to the pancreatic cancer diagnosis and the other concurrently with the pancreatic cancer diagnosis. Another male Livingston resident was diagnosed with undifferentiated small-cell carcinoma of the lung concurrent with the pancreatic cancer diagnosis. However, these cancers do not commonly metastasize to the pancreas; thus, they are unlikely to mimic the presentation of pancreatic cancer (17). The remaining decedent, who had diagnoses of two other cancers, was female and, thus, additional details of her illness would not have affected the principal conclusion of this study.

Potential Sources of Bias

Generating a hypothesis from a data set of multiple cancer-site categories and using the same data for preliminary testing of the hypothesis can increase the probability of chance observation of an apparently significant number of cases. Therefore, the Bonferroni method was used to compensate. Use of this correction, which is intended to guard against accepting a false hypothesis, is uncommon because it greatly increases the likelihood of rejecting a true association. Nevertheless, the analysis demonstrated a statistically significant increase in the number of pancreatic cancer deaths among white males in Livingston.

Because the Bonferroni correction was used, the appropriate criterion for judging whether each p value indicated the possibility of a statistically strong association with one of the residential categories was $p < 0.01$ (0.05 divided by 5, the number of digestive-system cancer sites that were considered). The p values of 0.0092 (with U.S. population age adjustment) and 0.0061 (with Montana population age adjustment) calculated for men in Livingston met this more stringent criterion.

Pancreatic cancer is difficult to diagnose accurately, especially with limited access to sophisticated imaging procedures. Numerous individual judgments in deciding what clinical tests to use in a diagnostic evaluation, how to interpret the results of those tests, how to read radiologic images, and how to interpret histologic sections created multiple possible sources of bias impossible to evaluate in hindsight. The information that was used to attribute deaths to pancreatic cancer in this study reflected the combined clinical judgments of a number of practitioners in different specialties. This problem was accentuated in the remote setting of Park County where state-of-the-art diagnostic methods of tertiary care centers were not routinely available and the diagnostic methods used were more subjective in interpretation.

Nevertheless, the diagnostic evaluations and medical records were as complete as possible, and the nosologic classifications made appeared to be sound, despite two possible misclassifications. The frequency of misclassification in the comparison data is not known, but such errors would at least partially correct for inclusion of any misclassified cases in this study.

CONCLUSIONS

1. Based on analysis of death certificates and available medical records, the observed number of pancreatic cancer deaths among Livingston men from 1980 through 1989 was elevated when compared with the age-adjusted number of deaths expected on the basis of U.S. and Montana pancreatic cancer mortality rates (1980 through 1988). This difference was statistically significant ($p = 0.0092$ with U.S. population age adjustment and $p = 0.0061$ with Montana population age adjustment).
2. Based on analysis of death certificates and available medical records, no significant increase in pancreatic cancer mortality was found in Park County exclusive of Livingston.
3. Based on a review of available medical records and the assumed prevalence of cigarette smoking in the study population, smoking did not appear to explain the observed increase in pancreatic cancer mortality. The apparent clustering of cases by occupation could not be evaluated with the available data.
4. Corroborative followup and study are required before conclusions can be drawn about the risk of pancreatic cancer in Livingston or Park County.

RECOMMENDATIONS

1. A more rigorous epidemiologic investigation should be considered to investigate further the association between pancreatic cancer and environmental factors in Livingston. Such a study should collect and analyze more complete information regarding medical history, residential and occupational history, and other known pancreatic cancer risk factors, such as smoking.
2. Residents of Livingston should be informed of the objectives, methods, findings, and conclusions of this study, including its methodologic limitations.

ACKNOWLEDGEMENTS

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Acknowledgements

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Funding

This study and final report were partially supported by funds from the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) trust fund.

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TABLES

Table 1.—Major cancer site groupings of cancer mortality data (1986-1988), provided for review by the Agency for Toxic Substances and Disease Registry.

ICD	Category
140-149	Malignant Neoplasms of Lip, Oral Cavity, and Pharynx
150-159	Malignant Neoplasms of Digestive Organs and Peritoneum
160-165	Malignant Neoplasms of Respiratory and Intrathoracic Organs
170-175	Malignant Neoplasms of Bone, Connective Tissue, Skin, and Breast
179-189	Malignant Neoplasms of Genitourinary Organs
190-199	Malignant Neoplasms of Other and Unspecified Sites (including Brain and Thyroid)
140-199	All Categories Listed Above

Source: Montana Department of Health and Environmental Sciences, Helena Montana

Table 2.—Observed and expected deaths from cancer, five digestive system sites, Park County, Montana, 1986-1988.

Diagnostic Category (Cancer Site)	ICD-9-CM Code	Observed Deaths In Park County (O)	Observed Deaths Not In Park County	Expected* Park County Deaths (E)	O:E Ratio
Stomach	151	4	153	2.7	1.48
Colon	153	12	833	14.6	0.82
Rectum, rectosigmoid junction, and anus	154	3	373	6.5	0.46
Gallbladder and extrahepatic bile ducts	156	2	52	0.9	2.22
Pancreas	157	7	179	3.2	2.19
Total		28	1,590	27.9	

*Expected numbers of Park County deaths for each diagnostic category were calculated in the manner used in the chi-squared analysis. That is, the ratio of observed Montana deaths for each code-specific cancer site to the total of Montana digestive tract cancer deaths was multiplied by the total number of Park County digestive tract cancer deaths.

Source: Montana Department of Health and Environmental Sciences, Helena, Montana

Table 3.—Crude and age-adjusted prevalence rates of cigarette smoking, U.S. resident population, 1965-1987.

	Male		Female	
Year	Crude	Age-Adjusted*	Crude	Age-Adjusted
1965	51.9	51.6	33.9	34.0
1974	43.1	42.9	32.1	32.5
1979	37.5	37.2	29.9	30.3
1983	35.1	34.7	29.5	29.9
1985	32.6	32.1	27.9	28.2
1987	31.2	31.0	26.5	26.7

*Age-adjusted to 1970 U.S. population.

Source: NCHS, Hyattsville, Maryland



Table 4.—Cancer diagnoses, sites other than pancreas, among decedents with pancreatic cancer as ascertained from medical records, Cluster Investigation of Pancreatic Cancer Deaths (1980-1989), Livingston and Park County, Montana, 1991.

Sex	Listed Residence	Cancer Site	Available Description of Tumor	Years Between Pancreatic Cancer Diagnosis and Other Site Diagnosis
Male	Livingston	Lung	None	10
		Larynx	None	15
Male	Livingston	Prostate	Metastatic	3
Male	Livingston	Prostate	Probable	0
Male	Livingston	Lung	Undifferentiated small cell carcinoma	0
Female	Livingston	Skin	Recurrent	Unknown
		Kidney	Clear cell	Unknown

Table 5.—Smoking history of decedents during previous 25 years as ascertained from medical records, Cluster Investigation of Pancreatic Cancer Deaths (1980-1989), Livingston and Park County, Montana, 1991.

Gender	Smokers	Nonsmokers	Unknown	Total
Livingston				
Male	6	4	1	11
Female	0	1	2	3
Total	6	5	3	14
Park County Exclusive Of Livingston				
Male	1	2	1	4
Female	0	2	0	2
Total	1	4	1	6
Park County				
Male	7	6	2	15
Female	0	3	2	5
Total	7	9	4	20

Table 6.—Decedents by gender, age group, and area of residence, Cluster Investigation of Pancreatic Cancer Deaths (1980-1989), Livingston and Park County, Montana, 1991.

	Livingston		Park County Exclusive Of Livingston		
Age Group (Years)	Males	Females	Males	Females	Total
< 39	0	0	0	0	0
40-44	1	0	0	0	1
45-49	0	0	0	0	0
50-54	0	0	0	0	0
55-59	0	0	1	0	1
60-64	1	1	1	0	3
65-69	1	1	0	1	3
70-74	2	0	1	0	3
75-79	4	0	1	1	6
80-84	0	0	0	0	0
≥ 85	2	1	0	0	3
Total	11	3	4	2	20
Arithmetic Mean (Years)	73	73	67	73	72

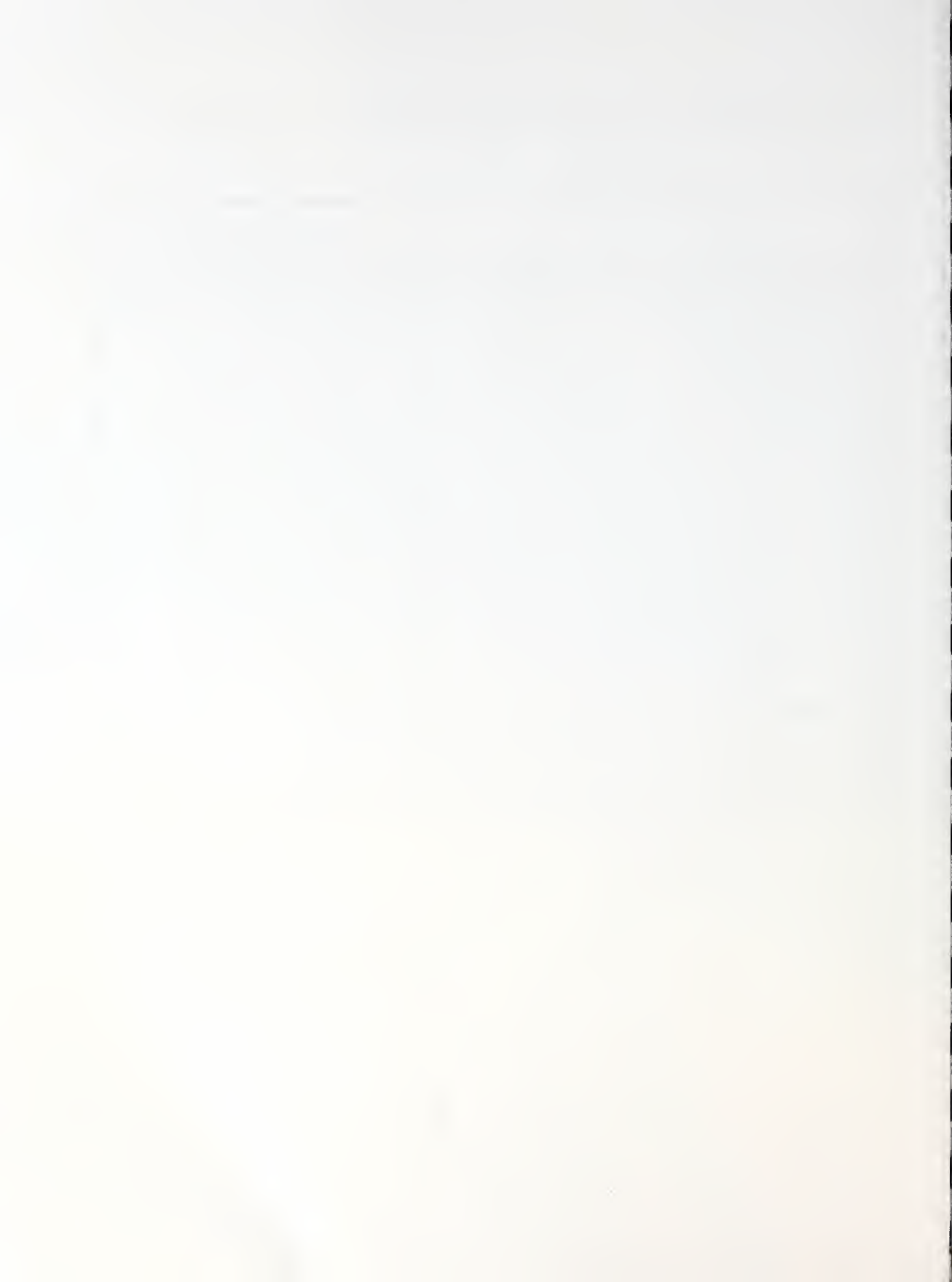


Table 7.—Occupations of decedents as ascertained from death certificates and medical records, Cluster Investigation of Pancreatic Cancer Deaths (1980-1989), Livingston and Park County, Montana, 1991.

Listed Residence	Occupation Category	Gender	Occupation
Livingston	Railroad	M	Railroad engineer
		M	Railroad engineer
		M	Railroad boilerman/welder
		M	Railroad blacksmith and toolmaker
	Other than railroad	M	Construction foreman/ operating engineer
		M	Rancher and prospector
		M	Rancher
		M	Ranch hand
		M	Police officer
		M	Baker
		M	Laborer/rancher/ automotive repairman
		F	Housewife
		F	Housewife
		F	Housewife
Park County exclusive of Livingston	Other than railroad	M	Rancher
		M	Rancher/salesman
		M	Accountant/rural letter carrier
		M	Mechanic
		F	Schoolteacher
		F	School Cook

Table 8.—Strength of association of increased number of pancreatic cancer deaths with residence in Park County, Cluster Investigation of Pancreatic Cancer Deaths (1980-1989), Livingston and Park County, Montana, 1991.

	Observed Deaths (O)	95% CI*	Expected† Deaths (E)	O:E Ratio	95% CI*	p value
Livingston						
Male	11	(6.2-19.7)	4.7 [4.4]	2.3 [2.5]	(1.3-4.2) [1.4-4.4]	0.0092 [0.0061]
Female	3	(1.1-8.8)	5.6 [4.9]	0.5 [0.6]	(0.2-1.6) [0.2-1.8]	0.92 [0.65]
Total	14	(8.4-23.5)	10.3 [9.4]	1.4 [1.5]	(0.8-2.3) [0.9-2.5]	0.16 [0.094]
Park County Exclusive Of Livingston						
Male	4	(1.6-10.2)	2.9 [2.9]	1.4 [1.4]	(0.6-3.6) [0.6-3.5]	0.32 [0.33]
Female	2	(0.6-7.2)	1.9 [2.3]	1.0 [0.9]	(0.3-3.7) [0.3-3.2]	0.58 [0.66]
Total	6	(2.8-13.1)	4.8 [5.1]	1.3 [1.2]	(0.6-2.7) [0.6-2.6]	0.35 [0.40]
Park County Total						
Male	15	(9.2-24.7)	7.6 [7.3]	2.0 [1.9]	(1.2-3.3) [1.3-3.4]	0.011 [.0085]
Female	5	(2.2-11.7)	6.8 [7.2]	0.7 [0.7]	(0.3-1.7) [0.3-1.6]	0.80 [0.84]
Total	20	(13.0-30.9)	14.3 [14.5]	1.4 [1.4]	(0.9-2.2) [0.9-2.1]	0.091 [0.097]

*CI= Confidence Interval (Poisson distribution)

†The number of deaths expected in each geographical area is the sum for all age groups of the product of the annual U.S. death rates for each 5-year age group per 100,000 total population times the population of that 5-year age group in the geographical area, times 10 years, divided by 100,000.

All numbers except those in square brackets are based on the 1980 through 1989 U.S. population; those in square brackets are based on the 1980 through 1988 Montana population.

Table 9.—Average annual, age-adjusted* pancreatic cancer death rates per 100,000 total population, Park County, Montana, for 1980-1989, Cluster Investigation of Pancreatic Cancer Deaths (1980-1989), Livingston and Park County, Montana, 1991.

	Livingston	Park County Exclusive of Livingston	Total Park County	United States 1980-1988	Montana 1980-1988
Male	23.6 [24.9]	14.3 [11.2]	20.0 [18.5]	10.1 [7.8]	[9.9]
Female	6.7 [10.0]	11.4 [3.9]	7.2 [8.3]	9.7 [8.5]	[9.6]
Total	15.0 [17.0]	13.2 [7.9]	14.0 [13.5]	9.9 [8.1]	[9.8]

*Adjusted to 1980-1989 U.S. population.

All numbers except those in square brackets are adjusted to the 1980 through 1989 U.S. population; those in square brackets are adjusted to the 1980 through 1988 Montana population.

FIGURES

[illegible]

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Source: Envirodon, Inc.

Figure 3.—Livingston Environmental cleanup site and residence of persons who died from pancreatic cancer, Livingston, Montana, 1980-1989, Cluster Investigation of Pancreatic Cancer Deaths, Livingston and Park County, Montana, 1991.

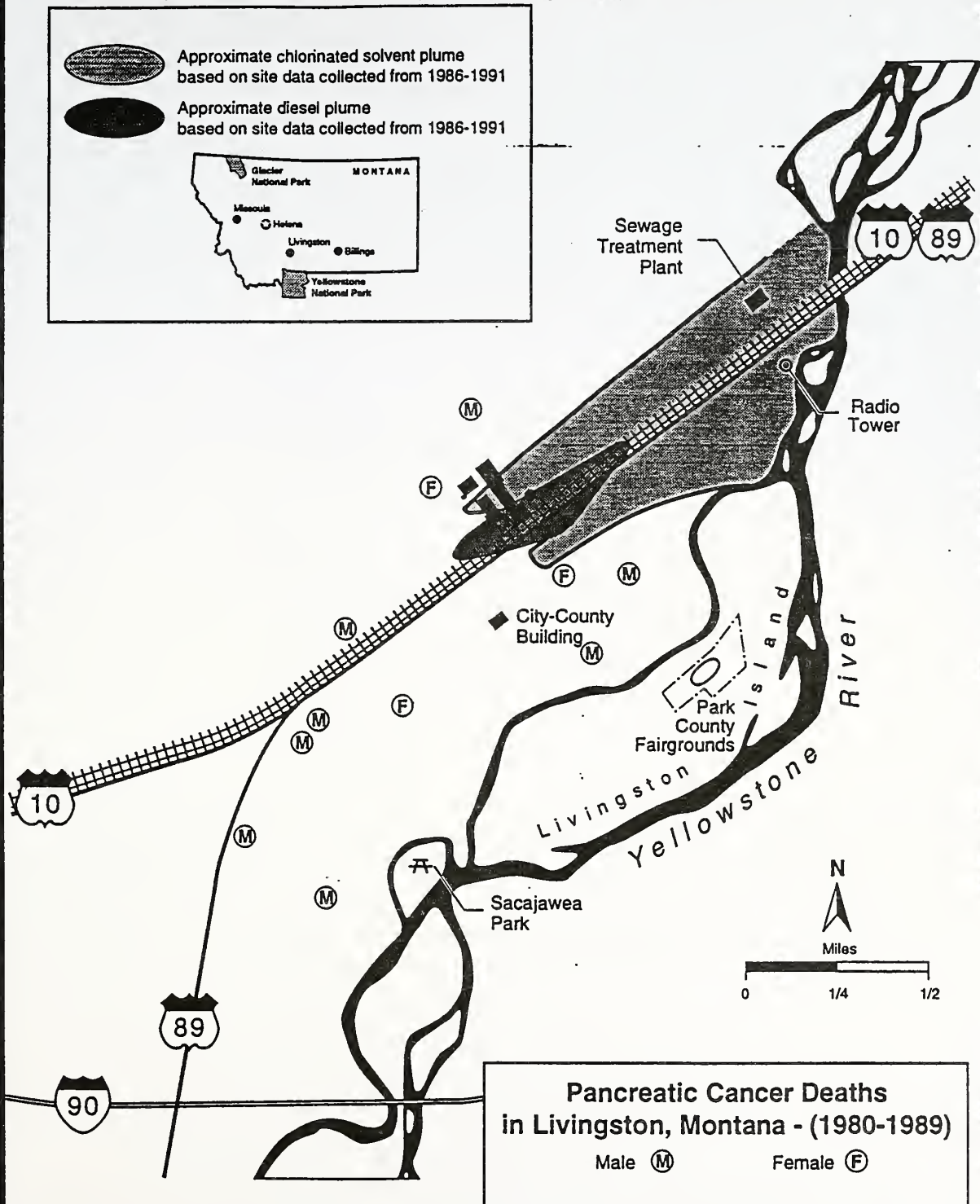




Figure 4.—Calculation of worst possible case estimate of increase in pancreatic cancer mortality attributable to smoking for Livingston, Montana, Cluster Investigation of Pancreatic Cancer Deaths, Livingston and Park County, Montana, 1991.

Let: R = crude U.S. pancreatic cancer mortality rate for males

R' = crude Livingston pancreatic cancer mortality rate for males

X = male population of Livingston, Montana

Assuming (1) the 1965 crude percentage of smokers in the U.S. male population of 52 percent from Table 3, (2) the threefold increase in pancreatic cancer risk for men who smoke more than 1.5 packs of cigarettes per day noted by Wynder et al (1983), and (3) the percentage of smokers observed in male cases in this study (60 percent) applied to the Livingston male population as a whole:

$$R = \frac{(.52)(3)X + (.48)X}{X} = 2.04$$

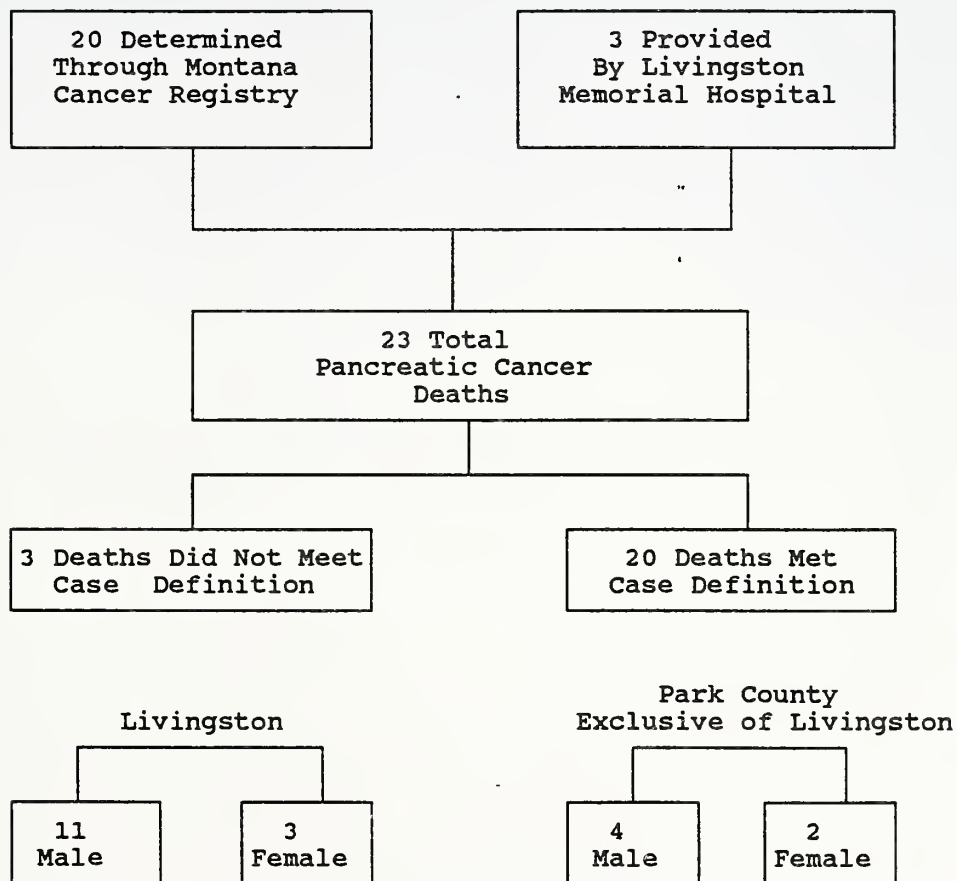
$$R' = \frac{(.60)(3)X + (.40)X}{X} = 2.20$$

Therefore:

$$R'/R = (2.20/2.04) = 1.07$$

Thus, the crude Livingston pancreatic cancer mortality rate for males would be expected to be increased by a factor of 0.07 or 7 percent over the crude U.S. pancreatic cancer mortality rate for males if the percentage of smokers observed among Livingston males in this study was assumed to represent the Livingston male population rather than the crude 1965 percentage of smokers in the male U.S. population. In fact, the percentage of smokers in the Livingston male population was probably lower and, hence, the increase in pancreatic cancer mortality attributable to smoking was probably less than 7 percent.

Figure 5.—Origin of information on pancreatic cancer deaths, place of residence, and gender. Cluster Investigation of Pancreatic Cancer Deaths, Livingston and Park County, Montana, 1991.



The contents of the Appendix are presented in their entirety as submitted by the Principal Investigator and have not been revised or edited to conform with Agency for Toxic Substances and Disease Registry guidelines.

Appendix
Medical Records Abstraction Form

DEPARTMENT OF
HEALTH AND ENVIRONMENTAL SCIENCES

APPENDIX



STAN STEPHENS, GOVERNOR

FAX #14061-4444, 495

STATE OF MONTANA

OFFICE: 206 Front Street
LOCATION: Helena, Montana

MAILING ADDRESS: Governor's Building
Helena, MT 59620

Medical Record Review

Study/subject number _____

Death Certificate # _____ Hospital Record # _____

Other Chart Locator Information _____

Date of Birth ____/____/____ Sex ____ Race _____

Address(es) _____

Clinical History

Primary Diagnosis: Tissue: _____ Date ____/____/____

Site: _____ Grade: _____ Stage: _____ Code: _____

At Hospital: _____ Metastasis? to? _____

(How Dx made, details of diagnostic process, other primaries)

Medical Record Review Study/subject number _____

Usual employment (as much history as is available—place of employment, job title/description, duties, exposures if known)

Spousal occupation(s)—place of employment, job title

Other significant information.

Continue on reverse, if needed. Continued (Y/N)? _____

Medical Record Review Study/subject number _____

Remarkable lab or procedure results (with date):

Who has tissue? _____

Secondary Diagnosis:

Smoking, alcohol, dietary history; medications; other risk factors
